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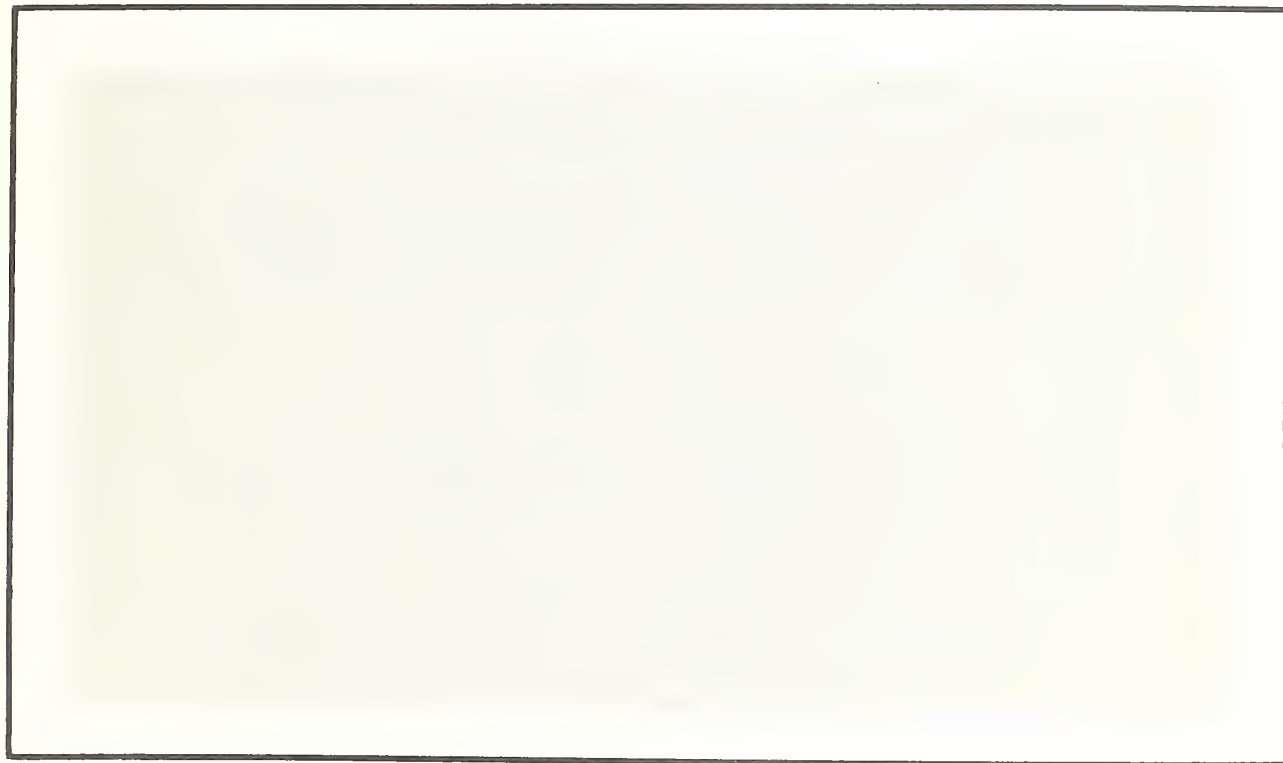
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Distribution of Suspended-Sediment Concentrations and Velocities in the Washita River

A Data Summary

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CONTENTS

	Page
Abstract	1
Introduction	1
Data-collection methods	2
Laboratory analyses	3
Data summaries for the five gaging sites	3
Anadarko	3
Verden	4
Chickasha, Fourth Street Bridge	4
Chickasha, turnpike bridge	5
Alex	5
Bed-material analyses for the five gaging sites	5
References	6

ILLUSTRATIONS

Fig.		
1.	Locations of the five gaging sites on the Washita River	2
2.	Bedrock breakoff below the Anadarko gaging site, viewed diagonally	3
3.	Verden gaging site, looking downstream	4
4.	Chickasha (Fourth Street Bridge) gaging site, looking downstream ..	4
5.	Alex gaging site, looking upstream	5

TABLES

1.	Distribution of sediment concentrations in the Washita River at Anadarko, Okla., May 13, 1964	7
2.	Distribution of velocities in the Washita River at Anadarko, Okla., May 13, 1964	8
3.	Distribution of sediment concentrations in the Washita River at Anadarko, Okla., November 6, 1964	9
4.	Distribution of velocities in the Washita River at Anadarko, Okla., November 6, 1964	11
5.	Distribution of sediment concentrations in the Washita River near Verden, Okla., November 7, 1964	13
6.	Distribution of velocities in the Washita River near Verden, Okla., November 7, 1964	15
7.	Distribution of sediment concentrations in the Washita River near Chickasha, Okla. (Fourth Street gage), June 26, 1963	16
8.	Distribution of velocities in the Washita River near Chickasha, Okla. (Fourth Street gage), June 26, 1963	18

	Page
9. Distribution of sediment concentrations in the Washita River near Chickasha, Okla. (turnpike gage), May 16, 1968	19
10. Distribution of velocities in the Washita River near Chickasha, Okla. (turnpike gage), May 16, 1968	20
11. Distribution of sediment concentrations in the Washita River near Alex, Okla., June 27, 1963	22
12. Distribution of velocities in the Washita River near Alex, Okla., June 27, 1963	24
13. Distribution of sediment concentrations in the Washita River near Alex, Okla., November 9, 1964	25
14. Distribution of velocities in the Washita River near Alex, Okla., November 9, 1964	27
15. Bed-material analyses for the five gaging sites	29

Distribution of Suspended-Sediment Concentrations and Velocities in the Washita River

A Data Summary

By Paul B. Allen¹

ABSTRACT

This report presents the methods used in collecting samples of suspended sediment and in measuring velocities during seven flows at five sites on the Washita River in southwestern Oklahoma to evaluate existing procedures for predicting sediment loads in unsampled portions of stream cross sections. Numerous samples were taken with a point-integrating suspended-sediment sampler to characterize sediment transport in the main body of flow, and velocities were recorded using various meter-weight arrangements that allowed measurement of velocities nearer the streambed than can be accomplished with conventional arrangements. Included are analyses of the sediment-concentration samples; summaries of the velocity data; and other related data, such as flow rates, water temperatures, and water-surface slopes. Index terms: hydrology, sediment sampling, sediment transport, suspended-sediment distribution, Washita River basin, water-velocity distribution.

INTRODUCTION

In the early 1960's, personnel of the Agricultural Research Service began collecting hydrologic data on a central segment of the Washita River basin between Anadarko and Alex in southwestern Oklahoma to determine the effects of upstream floodwater-control measures on downstream flow, sediment yield, and water quality. In collecting samples with depth-integrating suspended-sediment samplers, a part of the flow cross section could not be sampled because the distance from the nozzle to the sampler bottom

(between 0.25 and 0.50 foot) was fixed on any particular sampler used, thus leaving a portion of the cross section unsampled. Sediment transport for this unsampled zone had to be computed by two existing procedures (Colby and Hembree 1955, Colby 1957). Because computations by these procedures did not agree, seven flows at five measuring sites were intensively sampled and measured for velocity and sediment distribution in an effort to determine whether either method was sufficiently accurate to use. Results of the study were reported by Allen and Welch (1967a, 1967b) and Allen and Barnes (1975).

This report discusses the methods used in collecting samples of suspended sediment and in measuring velocities during seven flows at the Anadarko, Verden, Chickasha (Fourth Street Bridge), Chickasha (turnpike bridge), and Alex gaging sites on the Washita River to evaluate ex-

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isting procedures for predicting sediment loads in unsampled portions of stream cross sections. Also included in tabular form are summaries of the velocity data and analyses of the sediment-concentration samples.

Basic data of the kind collected in this study are not widely available and should be useful to other Federal personnel as well as to State and private workers in the sediment and water-pollution fields. These data will also be useful to certain university professors and their students for instruction and research. Data uses include (1) studying and improving existing two-dimensional sediment-concentration and velocity distribution relations and developing new ones, (2) evaluating sediment-transport procedures that use the above relations, (3) evaluating dispersion theory used for both mass and heat, and (4) illustrating qualitatively secondary-flow currents, a little understood but possibly significant consideration in sediment-transport processes.

DATA-COLLECTION METHODS

Figure 1 shows the locations of the five gaging sites on the Washita River where data were collected. At two sites, Anadarko and Alex, data collection was repeated at different flow rates. Selecting when and what flows to sample and measure was largely arbitrary. The only criteria were that the flow rate be sizable so that the sediment-transport rate would be significant and that the data be collected on or after hydrograph peaks to minimize the change in discharge (and velocity) and sediment concentrations during the data-collection period.

At each site, numerous samples were taken with a U.S. P-61 point-integrating suspended-sediment sampler. A type A crane, a four-wheel truck, and a power reel were used, except at the Chickasha site (Fourth Street Bridge) where a nonpowered reel was used. The stream verticals and the number of sampling points in each vertical were arbitrarily determined in the field at each site. The goal was to gain sufficient samples to characterize transport in the main body of flow. Samples were not collected near the banks where sediment transport appeared to represent only a small percentage of the total transport.

Point velocities were taken with a Price velocity meter at the same stream verticals, but not at



FIGURE 1.—Locations of the five gaging sites on the Washita River.

the same depths, as in the sediment data collections. The same type of suspension equipment used to suspend the sediment samplers in the flow was used to suspend and support the velocity meters. A 30-, 50-, or 100-pound weight was used at each site, depending upon the flow velocity.² When using the 50- or 100-pound weights, the meter was positioned closer to the weight to obtain near-bed velocities. The normal arrangement with these weights would have allowed measurements of only 0.9 foot from the bed with the 50-pound weight and 1.0 foot with the 100-pound weight.

An effort was made to determine the magnitude of error created by the closer meter position.

²The meter-weight arrangements used for each site are given in the footnotes to the velocity-distribution tables in this publication.



FIGURE 2.—Bedrock breakoff below the Anadarko gaging site, viewed diagonally.

Several velocity checks were made with both meter arrangements at depths higher in the flow cross section, but the results were inconclusive. Velocities were either about 5 percent high or 5 percent low at the closer position. However, near a boundary such as the streambed, readings were generally high.

LABORATORY ANALYSES

Each point sample was sieved in a wet condition to determine sand content (>0.062 millimeter). Both sand and fine fractions were oven-dried and weighed to determine the concentration of each fraction (and thus total concentration). Each sand fraction was treated with a strong ammonia solution to oxidize any organic matter present, soaked overnight, and run through a visual-accumulation tube apparatus to determine the percentages of each sand size. The percentages were multiplied by the total sand concentration to get the concentrations in each range of sand sizes.

DATA SUMMARIES FOR THE FIVE GAGING SITES

The Washita River in the reach from Anadarko to Alex is an alluvial stream except for a sandstone bed extending about the first 70 feet. The drainage area above the Anadarko gage is 3,656 square miles and increases to 4,787 square miles

at Alex. The average annual runoff at the Anadarko site is 0.86 inch but increases to 1.08 inches for the entire study reach because rainfall increases in an easterly direction and soils generally become finer textured. The average annual sediment yield is low at the Anadarko site (0.21 ton per acre) but increases for the reach to 0.93 ton per acre. Using fall velocity procedures and native stream water as a fall medium, sediment transported in the Washita River averages about 23 percent sand, 74 percent silt, and 3 percent clay. If distilled water were used and if the sediment were dispersed, the clay content would be about 10 percent higher and the silt about 10 percent lower.

Tables 1-4 summarize the sediment-concentration and velocity data for the five sites.³ Other related data and information are included in this report for each of the sites. The concentration data are not rounded because rounding data having random errors logically increases the error in about half the data. Rounding also creates a problem in that the sum of the rounded parts usually does not equal the rounded total. Therefore, although the concentration data are shown to five significant figures, five-place accuracy is not implied.

Apparently, no one knows the absolute magnitude of errors to be expected for concentrations determined from suspended-sediment samples. Errors include those inherent to the sampler, the sampling conditions, the operator, and the laboratory analyses. However, the small but uniform progression of silt and clay concentrations (<0.062 millimeter) with depth at each stream vertical (see sediment-concentration tables) suggests that most of the data have about two-place accuracy.

ANADARKO

A solid sandstone bed extends far upstream from this gaging site, but the rock breaks off about 70 feet downstream from the site. The photo in figure 2, taken when the river was dry, shows the bedrock breakoff. The sandstone has many indentations a few tenths of a foot deep that logically create turbulence.

³Distances across the stream for each site were determined from points on the left or right bank, facing downstream.



FIGURE 3.—Verden gaging site, looking downstream.

Tables 1 and 2 show sediment-concentration and velocity data collected May 13, 1964. The concentration data were collected between 1302 and 1430 hours (all times are reported as Central Standard Military Time), when the mean flow rate was 1,540 cubic feet per second. The velocity data were recorded between 1525 and 1625 hours, when the stage had fallen 0.3 foot and the flow rate was 1,430 cubic feet per second. The water temperature was 65° F, and the water-surface slope, as approximated later from a similar flow, was 0.00073 foot per foot.

Tables 3 and 4 show sediment-concentration and velocity data recorded November 6, 1964, during the same time interval, from 1330 to 1440 hours. The mean flow rate was 3,860 cubic feet per second, and the water temperature was 58° F. The water-surface slope was assumed to be the same as that for the earlier flow, 0.00073 foot per foot.

VERDEN

This gaging site (fig. 3), which is on the upstream side of a county bridge, has a drainage area of 4,083 square miles. Tables 5 and 6 show the sediment-concentration and velocity data collected November 7, 1964. The data for stream verticals 27, 33, and 39 were recorded between 1030 and 1230 hours, when the temperature was 55° F and the mean flow rate was 4,280 cubic feet per second. Because of an equipment breakdown, the data for stream verticals 45-81 were collected from 1600 to 1800 hours, when the stage was 0.8 foot higher, the flow rate was 4,580 cubic feet per



FIGURE 4.—Chickasha (Fourth Street Bridge) gaging site, looking downstream.

second, and the water temperature was 56° F. Velocity data for verticals 39 and 57 could not be obtained because of a large number of floating logs and other debris. The water-surface slope near the gaging site was 0.00030 foot per foot.

At this site, there are several wood pilings in the bed that protrude a few feet, possibly temporary supports used during bridge construction. These pilings have apparently caught logs near the bed just upstream from verticals 39 and 45, causing low sediment concentrations in those samples taken near the bed.

CHICKASHA, FOURTH STREET BRIDGE

The drainage area above this site is 4,259 square miles. The channel approaching this gaging site (fig. 4) is straight, and the width is narrower than at the other sites. These conditions create extra turbulence from bank roughness and result in quite uniform sediment distribution with depth.

Tables 7 and 8 show the data collected at this site June 26, 1963. This was the first study made, and because the data were collected by only a two-man crew and without a powered reel, the data-collection period was excessively long, about 5 hours. During this period, the mean sediment concentration fell from about 10,300 to 8,900 parts per million, the stage fell about 0.9 foot, and the discharge rate decreased from 2,210 to 1,850 cubic feet per second. Unfortunately, the falling concentration created an illusion that a lateral concentration gradient existed in the stream. The



FIGURE 5.—Alex gaging site, looking upstream.

water temperature remained constant at 77° F, and the water-surface slope was about 0.00036 foot per foot.

CHICKASHA, TURNPIKE BRIDGE

The drainage area above this site is 4,328 square miles. Tables 9 and 10 show the data collected May 16, 1968, when the flow rate was 2,020 cubic feet per second, the water temperature was 70° F, and the water-surface slope was 0.00023 foot per foot. During larger flows at this site, the bed scoured to bedrock at verticals 30, 36, and 42, as evidenced by the small volume of the samples collected with a U.S. BM-54 bed-material sampler. This condition was also evidenced by the low suspended-sand concentrations in samples taken at these same verticals, reflecting the "starved" bed-sand supply. A thread of coarse sand (0.500–1.000 millimeter) was moving in the vicinity of vertical 42, as evidenced by the coarse sand in the suspended-sediment sample taken near the bed. Sand particles in this range have been occasionally picked up in equal-transit-rate suspended-sediment samples at this site.

ALEX

The drainage area above this site is 4,787 square miles. The channel is wider and shallower here (fig. 5) than in other portions of the channel, the results of bed aggradation and bank erosion from the large, numerous flows and excessive

sand loads of the 1940's and 1950's (U.S. Agricultural Research Service 1982). A sharp bend to the right in the river a few hundred feet downstream from the gaging site had created a sand bar at the site on the inner banks between verticals 139 and 183.

Tables 11 and 12 show the data collected June 27, 1963. The flow rate during the data-collecting period was 1,250 cubic feet per second, the water temperature was 82° F, and the water-surface slope was 0.00032 foot per foot.

Tables 13 and 14 show the data collected November 9, 1964. Owing to downstream bank erosion flow lines had straightened at the gaging site and the sand bar had become less pronounced than in the previous study. Flow turbulence was less at this site, causing large gradients for sand concentration with stream depth. The reduced turbulence resulted from the wider stream that reduced the effects of bank roughness, the shallower flow, the fine bed sediment that reduced bed roughness, and the high sediment concentrations that increased the effective viscosity of the stream.

A problem limited exclusively to this site was the "soft" bed at places (the result of a highly mobile bed), making it difficult for the operator to determine when the sampler first touched the bed surface. Judging from the high sediment concentrations near the bed at verticals 150 and 180, it appears that the sampler sank into the bed; therefore, the reported depths are probably high, possibly by 0.1 or 0.2 foot.

The flow rate during the study on November 9 was 4,250 cubic feet per second, the water temperature was 57° F, and the water-surface slope was 0.00032 foot per foot.

BED-MATERIAL ANALYSES FOR THE FIVE GAGING SITES

Sediment in suspension is quite closely related to sediment in the streambed, and virtually all sediment-transport procedures require some form of bed-material data. Therefore, table 15 is included to show the percentages, on a weight basis, of material in each size range for each location. Three reference sizes, D_{35} , D_{50} , and D_{65} , are commonly used where 35 percent, 50 percent, and 65 percent (weight basis) of the streambed material consists of finer particles.

REFERENCES

- Allen, P. B., and Barnes, B. B.
 1975. Total sediment load by the extrapolated data procedure. *In* Present and Prospective Technology for Predicting Sediment Yields and Sources, pp. 100-108. U.S. Agric. Res. Serv. [Rep.] ARS-S-40.
- Allen, P. B., and Welch, N. H.
 1967a. Sediment transport of streams in the Washita River basin in Caddo and Grady Counties, Oklahoma. *Water Resour. Res.* 3(3): 777-784.
 1967b. Variations of sediment transport in the Washita River. *Int. Assoc. Sci. Hydrol. Publ.* 75, pp. 355-366.
- Colby, B. R.
 1957. Relationship of unmeasured sediment discharge to mean velocity. *Trans. Am. Geophys. Union* 38: 708-717.
- Colby, B. R., and Hembree, C. H.
 1955. Computations of total sediment discharge, Niobrara River near Cody, Nebraska. U.S. Geol. Surv. Water-Supply Pap. 1357, 119 pp.
- U.S. Agricultural Research Service.
 1982. Hydrology, erosion, and water-quality studies in the Southern Great Plains Research Watershed, southwestern Oklahoma, 1961-78. (In press.)

Table 1.—Distribution of sediment concentrations in the Washita River at Anadarko, Okla., May 13, 1964

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062-0.125	0.125-0.250	0.250-0.500	
231	2.7	(²)				
	2.4	5,043	226	34	0	5,303
	1.4	4,921	252	66	0	5,239
	.9	4,965	290	114	2	5,371
	.3	5,086	364	194	0	5,644
222	4.1	(²)				
	3.8	4,898	177	26	0	5,101
	2.6	4,835	214	104	13	5,166
	1.4	4,943	219	143	27	5,332
	.3	4,927	251	291	138	5,607
213	4.4	(²)				
	4.1	4,876	232	67	0	5,175
	2.9	4,831	240	148	13	5,232
	1.4	4,941	323	283	33	5,580
	.3	5,018	383	417	131	5,949
204	4.4	(²)				
	4.1	4,910	223	62	0	5,195
	2.9	4,952	386	332	0	5,670
	1.4	4,980	539	612	16	6,147
	.3	5,105	838	2,096	406	8,445
195	4.5	(²)				
	4.2	4,843	197	128	0	5,168
	2.9	5,066	321	284	13	5,684
	1.5	5,085	475	646	12	6,218
	.3	5,111	672	1,484	22	7,289
186	4.3	(²)				
	4.0	4,782	232	91	0	5,105
	2.7	4,903	322	212	0	5,437
	1.4	4,907	418	436	18	5,779
	.3	4,943	549	787	21	6,300
177	4.1	(²)				
	3.8	4,629	171	36	2	4,838
	2.5	4,758	220	83	4	5,065
	1.5	4,791	314	231	12	5,348
	.4	4,812	477	471	16	5,776
168	4.2	(²)				
	3.9	4,957	266	79	4	5,306
	2.5	4,874	322	156	0	5,352
	1.5	4,903	332	204	6	5,445
	.4	4,908	427	436	18	5,789
159	3.8	(²)				
	3.5	4,956	411	246	6	5,619
	2.4	5,038	504	313	0	5,855
	1.4	5,017	613	393	11	6,034
	.3	5,017	618	586	32	6,253

¹From an arbitrary initial point on left bank.

²Water surface.

Table 2.—Distribution of velocities in the Washita River at Anadarko, Okla., May 13, 1964

Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)	Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)
154	(³)	(³)			
	{	3.5	204	{	4.0
		3.2			3.7
		2.1			2.7
		1.1			1.8
		.5			.9
159		3.57			4.33
	{	4.0	213	{	4.0
		3.7			3.7
		2.7			2.7
		1.6			1.8
		1.0			.9
		.5			.5
168		4.86			4.41
	{	3.8	222	{	3.8
		3.5			3.5
		2.5			2.6
		1.8			1.8
		1.0			1.0
		.5			.5
177		4.86			3.33
	{	3.6	231	{	2.3
		3.3			2.0
		2.6			1.4
		1.7			.9
		1.1			.5
		.5			
186		5.73			3.10
	{	4.2	235		(⁵)
		3.9			(⁵)
		2.9			6.54
		2.1			6.17
		1.1			5.95
		.5			4.65
195		4.37			

¹From an arbitrary initial point on left bank.

²All velocities obtained while using a 30-lb. weight.

³Left edge of flow, zero depth.⁴Water surface.⁵Right edge of flow, zero depth.

Table 3.—Distribution of sediment concentrations in the Washita River at Anadarko, Okla.,
November 6, 1964

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062-0.125	0.125-0.250	0.250-0.500	
234	7.1	(²)				
	6.6	4,916	414	48	0	5,378
	5.6	4,912	590	112	0	5,614
	4.6	4,825	578	150	0	5,553
	3.6	4,779	570	132	0	5,481
	2.6	5,260	290	22	0	5,572
	1.7	5,431	168	6	0	5,605
	1.0	4,829	777	191	0	5,797
	.3	4,954	764	288	0	6,006
226	8.6	(²)				
	8.2	4,643	600	69	0	5,312
	7.0	4,641	450	83	0	5,174
	5.8	4,685	540	123	0	5,348
	4.6	4,714	702	243	0	5,659
	3.5	4,698	744	274	0	5,716
	2.3	4,798	757	355	0	5,910
	1.5	4,812	974	403	6	6,195
	.8	4,839	1,092	526	26	6,483
	.3	4,988	1,052	519	19	6,578
218	9.4	(²)				
	9.1	4,422	412	69	0	4,912
	7.9	4,566	436	71	0	5,073
	6.3	4,541	575	110	0	5,226
	4.9	4,592	775	247	0	5,614
	3.6	4,624	860	320	0	5,804
	2.5	4,714	942	362	18	6,036
	1.6	4,822	1,198	611	7	6,638
	1.3	4,747	1,182	729	20	6,678
	.3	4,825	1,320	1,092	44	7,281
210	9.6	(²)				
	9.3	4,330	283	19	0	4,632
	8.1	4,426	393	34	0	4,853
	6.5	4,462	540	134	0	5,136
	5.1	4,523	722	264	0	5,509
	3.8	4,589	917	290	0	5,796
	2.8	4,588	968	374	0	5,930
	1.8	4,690	1,280	468	0	6,438
	.9	4,737	1,500	814	21	7,072
	.3	4,710	1,768	1,620	157	8,255
202	9.8	(²)				
	9.3	4,298	290	18	0	4,606
	7.8	4,374	542	147	0	5,063
	6.0	4,335	621	154	0	5,110
	4.5	4,436	795	241	5	5,477
	3.0	4,456	895	294	11	5,656
	1.8	4,481	925	297	11	5,714
	.8	4,515	1,000	378	18	5,911
	.3	4,542	1,320	797	40	6,699

See footnotes at end of table.

Table 3.—Distribution of sediment concentrations in the Washita River at Anadarko, Okla., November 6, 1964—Continued

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062-0.125	0.125-0.250	0.250-0.500	
194	9.9	(²)	.....	.....	.....	.....
	9.4	4,288	248	5	0	4,541
	7.7	4,222	405	30	0	4,657
	5.9	4,334	359	33	0	4,726
	4.4	4,474	550	108	0	5,132
	3.0	4,371	678	124	0	5,173
	1.7	4,442	703	132	0	5,277
	.8	4,485	854	199	0	5,538
	.3	4,462	790	230	0	4,482
186	9.4	(²)	.....	.....	.....	.....
	9.1	4,237	296	18	0	4,551
	7.4	4,141	388	41	0	4,570
	5.9	4,225	380	32	0	4,637
	4.4	4,240	331	23	0	4,594
	2.8	4,268	504	112	0	4,884
	1.7	4,297	620	121	0	5,038
	.8	4,411	675	179	5	5,270
	.3	4,394	735	260	16	5,405
178	9.6	(²)	.....	.....	.....	.....
	9.1	4,305	449	45	0	4,799
	7.1	4,268	411	47	0	4,726
	5.1	4,169	517	57	0	4,743
	3.3	4,253	568	109	0	4,930
	1.8	4,289	668	143	0	5,100
	.8	4,248	784	226	0	5,258
	.3	4,293	732	247	5	5,277
170	9.7	(²)	.....	.....	.....	.....
	9.1	4,269	555	71	0	4,895
	7.5	4,318	603	107	0	5,028
	5.3	4,259	625	101	0	4,985
	3.3	4,312	716	111	0	5,139
	1.8	4,258	727	211	0	5,196
	.8	4,364	845	268	0	5,477
	.4	4,379	1,120	347	12	5,858
162	9.2	(²)	.....	.....	.....	.....
	8.9	4,312	668	63	0	5,043
	7.3	4,116	788	134	0	5,038
	5.3	4,306	733	143	0	5,182
	3.3	4,377	808	185	0	5,370
	1.8	4,396	933	217	0	5,546
	.8	4,507	1,023	297	0	5,827
	.3	4,356	1,163	368	0	5,887

¹From an arbitrary point on left bank.

²Water surface.

Table 4.—Distribution of velocities in the Washita River at Anadarko, Okla., November 6, 1964

Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)	Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)
247	(³)	(³)		9.8	(⁴)
				9.3	5.67
240	{ 3.7	(⁴)		8.8	4.68
	{ (⁵)	(⁵)		7.8	6.09
				6.8	6.09
	{ 7.3	(⁴)	202	{ 5.8	6.09
	{ 6.8	2.77		{ 4.8	5.98
	{ 6.1	3.16		{ 3.8	5.67
	{ 5.1	3.83		{ 2.8	5.35
234	{ 4.1	3.53		{ 2.1	5.23
	{ 3.1	3.53		{ 1.4	4.58
	{ 2.1	3.40		{ .9	4.19
	{ 1.4	3.02		{ .5	3.34
	{ .9	2.42			
	{ .5	1.79			
				{ 9.7	(⁴)
	{ 8.7	(⁴)		{ 9.2	6.32
	{ 8.2	3.53		{ 8.2	6.32
	{ 7.7	3.68	194	{ 7.2	6.44
	{ 6.7	3.83		{ 6.2	6.44
	{ 5.7	4.68		{ 4.7	6.44
226	{ 4.7	4.29		{ 3.7	6.57
	{ 3.7	4.58		{ 2.7	5.77
	{ 2.7	4.29		{ 2.1	5.58
	{ 2.1	3.83		{ 1.4	5.48
	{ 1.4	3.46		{ .9	5.35
	{ .9	3.02		{ .5	4.78
	{ .5	2.77			
				{ 9.8	(⁴)
	{ 9.5	(⁴)		{ 9.3	5.67
	{ 9.0	3.92		{ 8.8	6.32
	{ 8.5	4.19	186	{ 7.8	6.20
	{ 7.5	4.68		{ 6.8	6.57
	{ 6.5	4.99		{ 5.8	6.57
218	{ 5.5	4.99		{ 4.8	6.70
	{ 4.5	4.88		{ 3.8	6.57
	{ 3.5	4.78		{ 2.8	6.57
	{ 2.8	4.68		{ 2.1	6.20
	{ 2.1	4.49		{ 1.4	5.98
	{ 1.4	4.40		{ .9	5.48
	{ .9	4.19		{ .5	5.35
	{ .5	3.68			
				{ 9.6	(⁴)
	{ 10.1	(⁴)		{ 9.1	5.11
	{ 9.6	4.99		{ 8.1	5.35
	{ 9.1	4.99	178	{ 7.1	5.87
	{ 8.1	5.48		{ 6.1	6.20
	{ 7.1	5.48		{ 5.1	5.98
	{ 6.1	5.67		{ 4.1	6.09
210	{ 5.1	5.58		{ 3.1	5.67
	{ 4.1	5.35		{ 2.1	5.48
	{ 3.1	5.11		{ 1.4	5.23
	{ 2.1	4.88		{ .9	5.11
	{ 1.4	4.58		{ .5	4.68
	{ .9	4.29			
	{ .5	4.01			

See footnotes at end of table.

Table 4.—Distribution of velocities in the Washita River at Anadarko, Okla., November 6, 1964—Continued

Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)	Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)
170	9.6	(⁴)	150	{ 5.7	(⁴)
	9.1	4.01		{ (⁵)	(⁵)
	8.1	4.40			
	7.1	4.99	138	(⁶)	(⁶)
	6.1	5.23			
	5.1	5.48			
	4.1	5.48			
	3.1	5.23			
	2.1	4.88			
	1.4	4.99			
	.9	4.58			
	.5	4.10			
162	9.3	(⁴)			
	8.8	3.68			
	7.8	3.75			
	6.8	4.01			
	5.8	4.10			
	4.8	4.58			
	3.8	4.29			
	2.8	4.19			
	2.1	3.68			
	1.4	3.46			
	.9	3.09			
	.5	3.09			

¹From an arbitrary initial point on left bank.

²All velocities at 0.5-ft depth obtained while using a 30-lb weight; all other velocities obtained while using a 50-lb weight.

³Right edge of flow, zero depth.

⁴Water surface.

⁵No data taken.

⁶Left edge of flow, zero depth.

Table 5.—Distribution of sediment concentrations in the Washita River near Verden, Okla.,
November 7, 1964

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062-0.125	0.125-0.250	0.250-0.500	
27	11.1	(²)	.....	.....	.....	.....
	10.6	3,924	451	135	0	4,510
	7.3	3,988	508	158	0	4,654
	4.8	3,920	637	218	0	4,775
	2.8	3,997	572	200	0	4,769
	1.6	3,968	650	233	0	4,851
	.8	3,979	819	253	0	5,051
	.3	3,975	790	321	0	5,086
33	15.7	(²)	.....	.....	.....	.....
	15.2	3,927	410	111	0	4,458
	11.2	3,933	462	85	0	4,480
	7.7	4,071	555	193	0	4,819
	5.2	4,018	596	192	0	4,806
	3.2	4,018	740	375	0	5,133
	1.7	4,147	828	522	0	5,497
	.8	4,139	879	401	0	5,419
39	.3	4,259	1,160	747	0	6,166
	19.3	(²)	.....	.....	.....	.....
	18.8	3,866	392	96	0	4,354
	13.8	3,844	406	69	0	4,319
	8.8	3,976	575	322	0	4,873
	5.3	4,107	875	375	0	5,357
	3.3	4,088	646	356	0	5,090
	1.8	4,033	459	139	0	4,631
45	.8	2,473	628	329	0	3,430
	.3	(³)	(³)	(³)	(³)	4,053
	18.5	(²)	.....	.....	.....	.....
	17.5	3,626	373	61	0	4,060
	12.5	3,623	314	84	0	4,021
	8.5	3,688	433	119	0	4,240
	5.5	3,846	868	637	0	5,351
	3.5	3,852	884	520	0	5,256
51	2.0	3,921	1,010	616	0	5,547
	1.0	3,922	1,065	699	40	5,726
	.5	3,503	570	314	31	4,418
	16.8	(²)	.....	.....	.....	.....
	16.3	3,615	239	59	0	3,913
	12.3	3,565	400	114	0	4,079
	8.3	3,711	568	192	0	4,471
	5.3	3,785	820	390	0	4,995
51	3.3	3,847	985	665	33	5,530
	1.8	3,975	1,040	967	60	6,042
	.8	4,029	1,675	2,090	103	7,897
	.3	3,910	1,147	945	91	6,093

See footnotes at end of table.

Table 5.—Distribution of sediment concentrations in the Washita River near Verden, Okla., November 7, 1964—Continued

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062-0.125	0.125-0.250	0.250-0.500	
57	15.6	(²)	.....	.....	.....	.....
	15.1	3,586	349	68	0	4,003
	11.8	3,614	386	107	0	4,107
	8.3	3,659	498	169	0	4,326
	5.3	3,689	596	226	0	4,511
	3.3	3,153	1,740	472	0	5,365
	1.8	3,969	1,000	992	42	6,003
	.8	3,961	1,369	1,288	53	6,671
	.3	4,044	1,380	1,793	293	7,510
63	14.0	(²)	.....	.....	.....	.....
	13.5	3,675	423	84	0	4,182
	9.3	3,695	515	148	0	4,358
	5.3	3,730	611	217	0	4,558
	3.3	3,778	916	690	0	5,384
	1.8	3,855	1,024	841	35	5,755
	.8	3,847	1,214	1,083	43	6,187
	.3	3,898	1,742	2,610	168	8,418
69	13.2	(²)	.....	.....	.....	.....
	12.8	3,627	437	100	0	4,164
	9.8	3,648	507	137	0	4,292
	6.8	3,364	894	366	0	4,624
	4.8	3,561	811	289	0	4,661
	3.3	3,781	1,080	738	0	5,599
	1.8	3,866	1,150	1,180	12	6,208
	.8	3,866	1,490	1,525	49	6,930
	.3	4,014	1,579	1,972	61	7,626
75	12.7	(²)	.....	.....	.....	.....
	12.3	3,713	506	176	0	4,395
	9.3	3,775	677	315	0	4,767
	6.3	3,848	746	278	0	4,872
	4.3	3,777	785	565	0	5,127
	1.8	3,869	1,162	1,232	57	6,320
	.8	3,909	1,620	1,612	58	7,199
	.3	3,913	1,505	1,940	166	7,524
81	12.3	(²)	.....	.....	.....	.....
	11.8	3,825	652	281	0	4,758
	7.8	3,860	712	334	0	4,906
	4.3	3,834	900	556	0	5,290
	1.8	3,847	980	809	51	5,687
	.8	3,933	1,270	1,170	45	6,418
	.3	3,963	1,662	1,590	73	7,288

¹From an arbitrary initial point near top of right bank.

²Water surface.

³Data not available.

Table 6.—Distribution of velocities in the Washita River near Verden, Okla., November 7, 1964—Continued

Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)	Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)
84	11.5	(⁴)	96	6.7	(⁴)
	9.2	2.20		(⁶)	(⁶)
	2.3	2.44			
			113	(⁷)	(⁷)

¹From an arbitrary initial point on right bank.

²All velocities at 0.6-ft depth obtained while using 100-lb weight and with velocity meter set in lowest meter hole of hanger bar. All other velocities obtained with normal setting of velocity meter and 100-lb weight.

³Right edge of flow, zero depth.

⁴Water surface.

⁵Floating logs and other debris prevented data collection.

⁶Zero velocity.

⁷Left edge of flow, zero depth.

Table 7.—Distribution of sediment concentrations in the Washita River near Chickasha, Okla. (Fourth Street gage), June 26, 1963

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062-0.125	0.125-0.250	0.250-0.500	
24	4.7	(²)	.....	.....	.....	.....
	3.8	9,572	471	13	4	10,060
	2.8	9,600	557	44	11	10,212
	1.8	9,763	902	41	14	10,720
	.8	9,693	604	16	6	10,319
	.3	9,800	678	21	19	10,518
30	7.9	(²)	.....	.....	.....	.....
	7.3	9,309	266	14	11	9,600
	5.8	9,364	390	26	7	9,787
	4.3	9,419	520	53	7	9,999
	2.8	9,640	569	61	1	10,091
	1.8	9,456	561	53	6	10,076
	.8	9,499	736	118	7	10,360
	.3	9,672	881	129	9	10,691
36	10.7	(²)	.....	.....	.....	.....
	10.2	8,959	272	6	5	9,242
	9.1	9,118	444	38	7	9,607
	7.6	9,080	557	50	0	9,687
	6.1	9,177	589	58	4	9,828
	4.5	9,280	676	94	7	10,057
	3.0	9,341	626	107	3	10,077
	2.0	9,332	709	86	11	10,138
	1.3	9,315	711	114	7	10,147
	.8	9,316	697	127	9	10,149
	.3	9,379	758	122	8	10,267

See footnotes at end of table.

Table 7.—Distribution of sediment concentrations in the Washita River near Chickasha, Okla.
(Fourth Street gage), June 26, 1963—Continued

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062–0.125	0.125–0.250	0.250–0.500	
42	11.9	(²)	.....	.....	.....	.....
	10.5	8,855	478	39	2	9,374
	7.7	8,893	524	64	3	9,484
	5.3	8,923	520	130	3	9,576
	3.1	8,995	639	118	11	9,763
	1.8	9,003	828	221	11	10,063
	.8	9,022	920	345	25	10,312
	.3	9,085	1,152	581	61	10,879
48	11.2	(²)	.....	.....	.....	.....
	9.2	8,642	377	18	11	9,048
	6.8	8,660	442	53	1	9,156
	4.3	8,841	629	122	12	9,604
	2.3	8,849	589	99	4	9,541
	.8	8,897	671	393	16	9,977
	.3	9,163	1,110	408	25	10,706
57	11.1	(²)	.....	.....	.....	.....
	9.6	8,309	179	13	10	8,510
	7.3	8,337	288	26	2	8,653
	5.3	8,596	512	94	3	9,205
	3.3	8,609	576	113	3	9,301
	1.8	8,640	643	141	9	9,433
	.8	8,759	939	224	4	9,926
	.3	8,832	1,228	636	0	10,696
66	10.4	(²)	.....	.....	.....	.....
	6.3	8,496	386	24	8	8,914
	3.8	8,604	597	99	5	9,305
	1.8	8,784	902	204	9	9,899
	.8	8,890	976	202	0	10,068
	.3	9,120	1,199	346	26	10,691
75	10.0	(²)	.....	.....	.....	.....
	8.5	7,983	135	5	3	8,126
	5.8	8,204	467	55	2	8,728
	3.8	8,361	584	81	2	9,028
	1.8	8,545	801	146	2	9,494
	.8	8,440	583	108	14	9,145
	.3	8,488	980	269	10	9,747

¹From an arbitrary initial point on left bank.

²Water surface.

Table 8.—Distribution of velocities in the Washita River near Chickasha, Okla. (Fourth Street gage), June 26, 1963

Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)	Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)
14	(³)	(³)		11.2	(⁴)
				10.7	4.06
	4.5	(⁴)		9.9	4.35
	3.7	1.30		8.4	4.35
	3.2	1.04		6.9	4.16
24	2.7	.57	48	5.4	4.25
	2.2	.29		3.9	4.25
	1.7	.43		2.4	3.89
	1.2	.48		1.4	4.16
				.9	3.44
	8.0	(⁴)		11.1	(⁴)
	7.9	1.62		10.1	4.35
	6.4	2.61		8.4	4.35
30	4.9	2.35		6.9	4.35
	3.4	2.01	57	5.4	4.16
	2.4	1.74		3.9	4.35
	1.4	1.26		2.4	4.16
	.9	1.16		1.4	4.06
				.9	3.59
	10.6	(⁴)		10.3	(⁴)
	10.4	2.36		9.8	3.70
	9.4	3.20		8.4	4.02
	8.4	3.28		6.9	4.11
	7.4	3.13		5.4	4.21
36	5.9	2.31	66	3.9	4.02
	4.9	2.36		2.4	3.94
	3.4	1.66		1.4	3.94
	2.4	1.59		.9	3.63
	1.4	1.62		10.3	(⁴)
	.9	1.46		9.8	3.10
	11.7	(⁴)		8.5	2.84
	11.2	3.81		7.0	3.94
	9.9	3.74		5.5	3.85
	8.4	3.74	75	4.0	3.24
	6.9	3.66		2.5	3.17
42	5.4	3.71		1.5	3.08
	3.9	3.06		1.0	2.84
	2.9	2.31			
	1.9	2.87	86	(⁵)	(⁵)
	.9	2.56			

¹From an arbitrary initial point on left bank.

²All velocities obtained with normal setting of velocity meter and 100-lb weight.

³Right edge of flow, zero depth.

⁴Water surface.

⁵Left edge of flow, zero depth.

Table 9.—Distribution of sediment concentrations in the Washita River near Chickasha, Okla. (turnpike gage), May 16, 1968

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062-0.125	0.125-0.250	0.250-0.500	
18	6.1	(²)				
	5.1	6,105	270	50	0	5,425
	3.1	6,165	307	65	0	6,537
	1.6	6,254	369	87	0	6,710
	.6	6,309	548	263	0	7,120
	.3	6,230	309	39	0	6,578
24	8.6	(²)				
	7.6	6,078	248	25	0	6,351
	5.1	6,071	248	45	0	6,364
	1.8	6,155	307	65	0	6,527
	.8	6,303	467	202	0	6,972
	.3	6,242	355	107	0	6,704
30	9.6	(²)				
	8.6	6,009	193	25	0	6,227
	5.6	6,037	247	44	0	6,328
	2.1	6,129	300	91	0	6,520
	.8	6,080	332	104	0	6,516
	.3	6,133	308	118	0	6,559
36	10.3	(²)				
	9.3	5,997	186	37	0	6,220
	6.8	6,061	255	58	0	6,374
	2.5	6,122	371	139	0	6,632
	1.0	6,194	357	196	0	6,747
	.4	6,169	423	239	0	6,831
42	10.0	(²)				
	9.0	5,979	205	37	0	6,221
	5.5	6,034	228	76	0	6,338
	2.7	6,187	320	139	13	6,659
	.8	6,180	436	291	28	6,935
	.3	6,181	483	447	387	7,212
48	9.9	(²)				
	8.9	5,789	167	24	0	5,980
	5.4	5,945	271	82	0	6,298
	2.9	6,059	399	186	0	6,644
	.9	6,205	471	464	0	7,140
	.3	6,305	671	1,102	207	8,285
54	10.1	(²)				
	9.1	5,740	124	18	0	5,882
	5.6	5,985	280	89	0	6,354
	2.8	6,096	571	381	0	7,048
	.9	6,258	1,017	902	25	8,202
	.3	6,423	1,380	2,242	101	10,146
60	9.1	(²)				
	8.1	5,963	256	31	0	6,250
	3.1	5,991	1,031	448	0	7,470
	.9	6,368	1,202	898	0	8,468
	.3	6,409	1,337	1,374	37	9,157

See footnotes at end of table.

Table 9.—Distribution of sediment concentrations in the Washita River near Chickasha, Okla. (turnpike gage), May 16, 1968—Continued

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062-0.125	0.125-0.250	0.250-0.500	
66	8.7	(²)	.....	.....	.....	.....
	7.7	6,154	349	86	0	6,589
	3.0	6,244	862	327	0	7,433
	.8	6,352	1,108	401	0	7,861
	.3	6,391	1,011	498	0	7,900
72	6.6	(²)	.....	.....	.....	.....
	5.6	6,135	557	95	0	6,787
	2.1	6,264	899	267	0	7,430
	.8	6,287	1,058	436	0	7,781
	.3	6,377	1,207	518	0	8,102
78	4.4	(²)	.....	.....	.....	.....
	2.9	6,032	345	19	0	6,396
	.3	6,160	853	217	0	7,230

¹From an arbitrary initial point on left bank.

²Water surface.

³This sample had 14 p/m of sand 0.500-1.000 mm in size.

Table 10.—Distribution of velocities in the Washita River near Chickasha, Okla. (turnpike gage), May 16, 1968

Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)	Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)
12	(³)	(³)	30	9.7	(⁴)
18	5.9	(⁴)		8.7	4.27
	5.3	1.06		7.7	4.49
	4.7	1.08		6.3	4.54
	3.7	1.54		4.9	4.54
	2.7	1.83		3.4	4.32
	1.7	1.76		2.4	3.90
	1.1	1.83		1.7	3.52
	.55	1.63		1.0	2.94
24	8.5	(⁴)		.55	2.15
	6.8	2.89	36	10.5	(⁴)
	5.5	3.15		9.8	4.74
	4.5	3.39		8.4	4.63
	3.4	3.39		6.5	4.27
	2.4	3.56		4.9	3.83
	1.7	3.56		3.6	3.56
	1.0	3.42		2.7	3.20
	.55	2.98		2.0	2.65
				1.1	1.84
				.55	1.64

See footnotes at end of table.

Table 10.—Distribution of velocities in the Washita River near Chickasha, Okla. (turnpike gage), May 16, 1968—Continued

Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)	Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)
42	10.1	(⁴)	66	8.7	(⁴)
	9.5	4.79		7.0	4.27
	8.1	4.95		5.3	4.36
	6.1	4.79		3.7	4.15
	4.1	4.54		2.5	3.49
	2.9	4.07		1.6	3.24
	2.1	3.50		1.0	3.04
	1.5	2.91		.55	2.57
	1.0	2.44			
	.55	2.19			
48	10.1	(⁴)	72	6.7	(⁴)
	9.5	4.95		6.0	2.85
	8.1	5.01		5.4	3.21
	6.1	4.95		4.5	3.39
	4.1	4.73		3.0	2.63
	2.9	4.27		2.2	2.10
	2.1	4.06		1.5	2.28
	1.5	3.90		1.0	1.75
	1.0	3.21		.55	1.98
	.55	2.94			
54	10.1	(⁴)	78	4.2	(⁴)
	8.1	5.07		3.4	.51
	6.1	5.01		2.9	.81
	4.1	4.54		2.1	.55
	2.9	4.04		1.5	.81
	2.1	3.42		1.0	.99
	1.5	3.71		.55	.81
	1.0	3.12	81	3.6	(⁴)
	.55	2.28		(⁵)	(⁵)
60			85	(⁶)	(⁶)
	9.1	(⁴)			
	7.3	4.73			
	5.8	4.84			
	4.1	4.45			
	2.7	3.71			
	1.9	3.36			
	1.4	3.04			
	1.0	2.66			
	.55	2.67			

¹From an arbitrary initial point on left bank.

²All velocities at 0.55-ft depth obtained while using 50-lb weight and with velocity meter set in next to lowest meter hole of hanger bar. All other velocities obtained with normal setting of velocity meter and 50-lb weight.

³Left edge of flow, zero depth.

⁴Water surface.

⁵Zero velocity.

⁶Right edge of flow, zero depth.

Table 11.—Distribution of sediment concentrations in the Washita River near Alex, Okla., June 27, 1963

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062-0.125	0.125-0.250	0.250-0.500	
225	7.0	(²)	.....	.....	.....	.....
	5.3	6,073	277	42	0	6,392
	4.3	6,229	320	51	0	6,600
	1.8	6,300	441	85	0	6,826
	.8	6,206	439	130	0	6,775
	.3	6,441	497	286	0	7,224
218	6.4	(²)	.....	.....	.....	.....
	5.3	6,054	371	56	0	6,481
	3.3	6,430	468	79	0	6,977
	1.8	6,356	553	136	0	7,045
	.8	6,340	737	295	0	7,372
	.3	6,415	776	434	0	7,625
211	5.5	(²)	.....	.....	.....	.....
	5.0	6,005	247	27	0	6,279
	3.3	6,352	420	40	0	6,812
	1.8	6,382	771	172	0	7,325
	.8	6,502	1,062	358	0	7,922
	.3	6,457	1,067	267	12	7,803
204	4.5	(²)	.....	.....	.....	.....
	3.3	6,085	344	27	0	6,456
	1.8	6,625	829	144	0	7,598
	.8	6,775	1,189	179	0	8,143
	.3	6,843	2,088	552	0	9,483
197	3.6	(²)	.....	.....	.....	.....
	2.8	6,007	233	30	0	6,270
	.8	6,695	1,404	189	0	8,288
	.3	6,815	2,295	438	16	9,564
190	3.0	(²)	.....	.....	.....	.....
	2.5	5,888	225	30	0	6,143
	1.8	6,053	440	91	9	6,593
	.8	6,411	892	273	7	7,583
	.3	6,525	1,827	909	0	9,261
183	2.3	(²)	.....	.....	.....	.....
	1.7	5,874	175	16	0	6,071
	.8	6,064	627	190	7	6,888
	.3	6,412	2,297	838	22	9,569
176	2.0	(²)	.....	.....	.....	.....
	1.4	5,627	197	24	10	5,858
	.8	6,050	575	44	5	6,674
	.3	6,235	1,569	338	2	8,144
169	1.7	(²)	.....	.....	.....	.....
	1.3	5,548	195	15	5	5,763
	.8	5,727	459	35	7	6,228
	.3	6,157	1,431	281	0	7,869

See footnotes at end of table.

Table 11.—Distribution of sediment concentrations in the Washita River near Alex, Okla., June 27, 1963—Continued

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062-0.125	0.125-0.250	0.250-0.500	
162	1.5	(²)	.....	.....	.....	.....
	1.1	5,712	223	11	11	5,957
	.7	5,764	451	28	11	6,254
	.3	6,095	1,036	88	8	7,227
155	1.2	(²)	.....	.....	.....	.....
	.7	5,845	346	7	0	6,198
	.3	5,929	677	19	11	6,636
147	1.0	(²)	.....	.....	.....	.....
	.7	5,758	298	23	0	6,079
	.3	6,146	914	38	5	7,103
139	1.0	(²)	.....	.....	.....	.....
	.7	5,645	131	10	0	5,786
	.3	5,900	459	25	0	6,384

¹From an arbitrary initial point on right bank.

²Water surface.

Table 12.—Distribution of velocities in the Washita River near Alex, Okla., June 27, 1963

Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)	Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)
245	(³)	(³)			
234-231	(⁴)	(⁴)	190	{ 3.0 2.4 1.9 1.4 .9	(⁵) 4.80 4.68 4.58 4.29
225	{ 7.0 6.4 5.9 4.9 2.9 1.4 .9	(⁵) 2.08 1.98 2.83 2.89 2.77 2.53	183	{ 2.2 1.9 1.4 .9	(⁵) 4.78 4.68 4.40
218	{ 6.5 5.9 5.4 4.4 3.4 2.4 1.4 .9	(⁵) 4.10 4.19 3.87 3.46 3.22 2.64 2.58	176	{ 1.9 1.4 .9	(⁵) 4.49 4.40
211	{ 5.3 4.9 4.4 3.9 2.9 1.9 1.4 .9	(⁵) 4.99 4.78 4.58 4.10 3.68 3.53 3.27	169	{ 1.7 1.5 .9	(⁵) 4.10 4.01
204	{ 4.4 3.9 3.4 2.4 1.4 .9	(⁵) 4.99 5.40 4.58 3.53 4.01	162	{ 1.5 1.3 .9	(⁵) 3.60 3.83
197	{ 3.5 2.9 2.4 1.4 .9	(⁵) 5.23 4.99 4.68 4.19	155	{ 1.2 .9	(⁵) 3.53
			147	{ 1.0 .5	(⁵) 3.02
			139	{ 1.0 .5	(⁵) 2.53
			131	{ 1.0 .5	(⁵) 1.23
			126	(⁶)	(⁶)

¹From an arbitrary initial point on right bank.

²All velocities obtained while using a 50-lb weight, except locations 131, 139, and 147 where 30-lb weight was used.

³Left edge of flow, zero depth.

⁴Bridge pier.

⁵Water surface.

⁶Right edge of flow, zero depth.

Table 13.—Distribution of sediment concentrations in the Washita River near Alex, Okla., November 9, 1964

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062–0.125	0.125–0.250	0.250–0.500	
140	7.2	(²)	.....	.....	.....	.....
	6.7	5,175	664	29	0	5,868
	5.7	5,426	1,078	112	0	6,616
	4.2	5,966	1,680	283	0	7,857
	3.2	5,967	2,150	436	0	8,553
	1.8	5,920	2,535	775	0	9,230
	.8	6,087	3,560	2,000	0	11,647
	.3	6,027	4,400	2,690	0	13,117
150	6.8	(²)	.....	.....	.....	.....
	6.3	5,181	525	6	0	5,712
	5.3	5,491	1,250	116	0	6,857
	3.8	5,635	1,550	162	0	7,347
	2.8	6,106	2,355	298	0	8,759
	1.8	6,236	3,840	620	0	10,696
	.8	7,500	12,180	2,995	0	22,675
	.3	8,151	24,400	13,930	0	46,481
160	6.1	(²)	.....	.....	.....	.....
	5.6	4,865	234	0	0	5,099
	4.6	5,261	662	42	0	5,965
	3.6	5,630	1,010	53	0	6,693
	2.6	5,878	1,736	140	0	7,754
	1.6	6,139	2,400	282	0	8,821
	.8	6,750	4,020	555	0	11,325
	.3	6,889	7,510	1,928	0	16,327
170	7.2	(²)	.....	.....	.....	.....
	6.7	4,767	168	0	0	4,935
	5.7	5,174	238	0	0	5,412
	4.2	5,476	1,160	67	0	6,703
	3.2	5,621	1,548	161	0	7,330
	2.2	5,871	2,190	266	0	8,327
	1.5	6,237	3,220	733	0	10,190
	.8	6,369	5,250	1,690	0	13,309
	.3	7,472	11,300	3,760	0	22,532
180	7.8	(²)	.....	.....	.....	.....
	7.3	4,772	107	0	0	4,879
	6.3	5,287	485	6	0	5,778
	4.8	5,363	684	55	0	6,102
	3.8	5,487	1,125	87	0	6,699
	2.8	5,694	1,792	377	0	7,863
	1.8	5,897	2,140	531	0	8,568
	.8	5,921	2,740	1,270	0	9,931
	.3	6,409	4,875	4,000	0	15,284

See footnotes at end of table.

Table 13.—Distribution of sediment concentrations in the Washita River near Alex, Okla., November 9, 1964—Continued

Distance across stream ¹ (ft)	Distance above streambed (ft)	Parts per million for particle sizes (mm) of—				Total for all sizes (p/m)
		<0.062	0.062–0.125	0.125–0.250	0.250–0.500	
190	7.8	(²)	.....	.....	.....	.....
	7.3	4,765	198	0	0	4,963
	6.3	5,256	590	0	0	5,846
	4.8	5,316	916	88	0	6,320
	3.8	5,477	1,352	218	0	7,047
	2.8	5,631	1,533	244	0	7,408
	1.8	5,533	1,562	461	0	7,556
	.8	5,799	2,800	1,611	0	10,210
	.3	5,886	4,170	2,705	0	12,761
200	7.9	(²)	.....	.....	.....	.....
	7.4	4,677	155	0	0	4,832
	6.4	5,194	750	85	0	6,029
	4.9	5,283	1,130	226	0	6,639
	3.4	5,392	1,222	297	0	6,911
	2.4	5,350	1,360	436	0	7,146
	1.4	5,388	1,348	437	0	7,173
	.8	5,548	1,620	752	0	7,920
	.3	5,464	2,520	1,900	0	9,884
210	8.5	(²)	.....	.....	.....	.....
	7.5	4,640	303	30	0	4,973
	6.5	5,130	664	130	0	5,924
	5.0	5,207	1,000	192	0	6,399
	4.0	5,200	985	291	0	6,476
	3.0	5,237	1,045	324	0	6,606
	2.0	5,242	1,141	336	0	6,719
	1.0	5,375	1,285	603	0	7,263
	.3	5,486	1,948	2,545	0	9,979
220	9.1	(²)	.....	.....	.....	.....
	8.6	5,015	602	168	0	5,785
	7.6	4,973	627	97	0	5,697
	6.1	5,059	739	161	0	5,959
	4.6	5,164	842	231	0	6,237
	3.6	5,193	952	330	0	6,475
	2.6	5,232	930	379	0	6,541
	1.6	5,225	1,000	390	0	6,615
	.8	5,084	896	375	0	6,355
	.3	5,285	1,489	1,320	0	8,094

¹From an arbitrary initial point on right bank.

²Water surface.

Table 14.—Distribution of velocities in the Washita River near Alex, Okla., November 9, 1964

Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)	Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)
104	(³)	(³)		8.4	(⁴)
				7.9	6.86
125	{ 6.5	(⁴)		6.9	7.01
	{ (³)	(³)		5.9	6.86
				4.9	6.86
	{ 7.4	(⁴)	180	{ 3.9	6.46
	{ 6.4	5.78		2.9	5.89
	{ 5.4	5.89		2.1	5.50
	{ 4.6	5.68		1.5	4.68
140	{ 3.8	5.23		1.0	3.67
	{ 2.9	4.68		.6	3.91
	{ 2.1	3.30			
	{ 1.5	2.57		8.3	(⁴)
	{ 1.0	1.84		7.8	7.01
	{ .6	1.70		7.3	7.01
				6.3	6.86
	{ 6.6	(⁴)	190	{ 5.3	6.72
	{ 6.1	6.46		4.3	6.46
	{ 5.1	6.59		3.3	6.10
150	{ 4.1	6.59		2.3	5.68
	{ 3.1	6.34		1.6	5.00
	{ 2.3	5.99		1.0	5.36
	{ 1.5	5.50		.6	4.00
	{ 1.0	5.11			
	{ .6	3.93		8.3	(⁴)
				7.8	6.72
	{ 6.9	(⁴)	200	{ 6.8	6.72
	{ 6.4	6.59		5.8	6.59
	{ 5.4	7.01		4.8	6.46
160	{ 4.4	6.86		3.8	6.10
	{ 3.4	6.59		2.8	5.59
	{ 2.6	6.22		2.2	5.23
	{ 1.9	5.78		1.5	5.00
	{ 1.4	5.36		1.0	5.00
	{ 1.0	5.23		.6	4.40
	{ .6	3.91			
				8.5	(⁴)
	{ 6.9	(⁴)	210	{ 8.0	6.59
	{ 6.4	6.59		7.5	6.59
	{ 5.4	7.01		6.5	6.34
170	{ 4.4	6.86		5.5	5.99
	{ 3.4	6.58		4.5	5.50
	{ 2.4	6.10		3.5	5.59
	{ 1.6	5.78		2.7	5.23
	{ 1.0	5.23		2.0	4.68
	{ .6	4.78		1.5	4.78
				1.0	4.40
				.6	4.00

See footnotes at end of table.

Table 14.—Distribution of velocities in the Washita River near Alex, Okla., November 9, 1964—Continued

Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ¹ (ft/s)	Distance across stream ¹ (ft)	Distance above streambed (ft)	Velocity ² (ft/s)
220	9.0	(⁴)	228	11.4	(⁴)
	8.5	3.34		(⁶)	(⁶)
	8.0	3.55	231-234	(7)	(7)
	7.0	4.15			
	6.0	4.89			
	5.0	5.36	250	(8)	(8)
	4.0	4.89			
	3.3	5.00			
	2.5	5.00			
	2.0	4.49			
	1.5	4.09			
	1.0	4.00			
	.6	3.52			

¹From an arbitrary initial point on right bank.

²All velocity at 0.6-ft depth obtained while using 100-lb weight and with velocity meter set in lowest meter hole of hanger bar. All other velocities obtained with normal setting of meter and 100-lb weight.

³Right edge of flow, zero depth.

⁴Water surface.

⁵Reverse flow caused by large eddy.

⁶No data taken.

⁷Bridge pier.

⁸Left edge of flow, zero depth.

Table 15.—Bed-material analyses for the five gaging sites¹

Distance across stream (ft)	Percentage of total sample (by weight) for particle sizes (mm) of—						Particle sizes (mm) finer than sizes represented by—		
	<0.062	0.062-0.125	0.125-0.250	0.250-0.500	0.500-1.00	>1.00	D ₃₅	D ₅₀	D ₈₅
Anadarko—May 13, 1964									
² 231	53.3	11.4	17.7	17.6	0.0	0.0	.....	.....	0.129
² 222	48.0	16.0	22.2	13.8	.0	.0	.....	0.072	.129
213	1.4	4.0	53.9	40.2	.5	.0	0.220	.240	.260
204	1.0	6.8	71.0	20.4	.8	.0	.180	.199	.218
195	24.5	4.0	30.8	38.2	2.5	.0	.160	.215	.270
³ 186	.....	.....	.....	.....	.....	.....	.....	.....	.....
² 177	66.0	18.0	15.0	1.0	.0	.0	.....	.....	.....
² 168	60.8	15.5	17.7	6.0	.0	.0	.....	.....	.076
² 159	38.7	13.3	29.8	16.6	1.6	.0	.....	.117	.170
Anadarko—Nov. 6, 1964									
² 234	31.5	24.0	38.8	5.7	.0	0.0	0.076	0.115	0.145
² 226	31.0	14.0	40.0	14.0	1.0	.0	.094	.135	.172
218	4.4	6.4	59.3	27.7	2.2	.0	.170	.196	.232
210	4.9	9.1	67.4	18.6	.0	.0	.168	.190	.215
202	7.7	3.3	31.0	53.5	4.5	.0	.227	.270	.315
² 198	56.5	14.4	14.2	13.9	1.0	.0	.....	.....	.090
² 190	74.1	13.1	8.2	4.6	.0	.0	.....	.....	.....
² 182	83.7	11.7	4.2	.4	.0	.0	.....	.....	.....
² 174	84.9	11.1	4.2	.0	.0	.0	.....	.....	.....
² 166	62.1	16.1	11.1	6.7	4.0	.0	.....	.....	.068
² 158	77.8	14.0	6.7	1.5	.0	.0	.....	.....	.....
Verden—Nov. 6, 1964									
⁴ 33	92.5	1.6	2.1	3.6	0.2	0.0	.....	.....	.....
⁴ 41	69.4	5.1	9.8	13.9	1.8	.0	.....	.....	.....
49	2.1	4.9	37.0	50.9	5.1	.0	0.222	0.270	0.320
57	1.6	3.4	48.1	41.8	5.1	.0	.210	.244	.282
65	1.7	3.3	55.8	35.3	3.9	.0	.196	.225	.260
73	2.0	9.0	67.8	21.2	.0	.0	.166	.186	.212
Chickasha (4th St. gage)—June 26, 1963									
24	22.0	64.5	11.8	0.7	0.0	0.0	0.078	0.087	0.096
⁴ 30	55.3	37.7	7.0	.0	.0	.0	.041	.063	.079
⁴ 36	70.4	14.1	10.8	4.7	.0	.0	.017	.032	.056
42	2.8	9.9	47.0	39.3	1.0	.0	.200	.233	.260
48	2.9	4.9	45.2	46.3	.7	.0	.220	.245	.270
57	4.8	18.5	59.9	15.8	1.0	.0	.142	.168	.200
66	1.6	25.7	64.7	8.0	.0	.0	.129	.139	.158
75	6.0	55.3	37.0	1.7	.0	.0	.097	.111	.130

See footnotes at end of table.

Table 15.—Bed-material analyses for the five gaging sites¹—Continued

Distance across stream (ft)	Percentage of total sample (by weight) for particle sizes (mm) of—						Particle sizes (mm) finer than sizes represented by—		
	<0.062	0.062-0.125	0.125-0.250	0.250-0.500	0.500-1.00	>1.00	D ₃₅	D ₅₀	D ₆₅
Chickasha (turnpike gage)—May 16, 1968									
⁴ 24	68.7	12.0	6.4	1.9	1.0	10.0	.....	.....	.....
⁴ 30	.....	.....	.....	.....	.....	.....	.....	.....	.....
² 36	4.2	6.6	54.9	30.8	3.3	.2	0.190	0.220	0.250
² 42	6.9	2.4	10.7	22.8	47.1	10.1	.415	.542	.650
48	2.5	5.0	39.8	26.7	21.2	4.8	.203	.259	.352
54	15.2	6.7	24.4	12.0	26.5	15.2	.177	.295	.580
60	31.8	9.7	22.4	8.7	15.5	11.9	.084	.160	.300
² 66	26.0	17.5	27.0	9.9	8.4	11.2	.099	.142	.200
² 72	28.0	38.0	23.5	2.5	2.4	5.6	.072	.100	.123
Alex—June 27, 1963									
225	2.2	17.1	73.2	7.5	0.0	0.0	0.142	0.160	0.175
218	2.9	30.4	64.4	2.3	.0	.0	.128	.140	.155
211	2.7	12.3	76.5	7.7	.8	.0	.150	.167	.178
204	1.3	30.0	67.0	1.7	.0	.0	.126	.141	.157
197	2.1	41.2	55.9	.8	.0	.0	.120	.131	.145
190	1.7	40.1	57.6	.6	.0	.0	.120	.130	.145
183	1.8	59.1	39.1	.0	.0	.0	.114	.121	.126
176	2.8	60.1	36.4	.7	.0	.0	.106	.116	.128
169	1.5	60.3	37.8	.4	.0	.0	.118	.122	.128
162	3.6	64.4	30.7	.3	.0	.0	.104	.112	.121
155	9.3	75.0	15.1	.6	.0	.0	.096	.107	.116
147	7.1	76.5	15.7	.7	.0	.0	.098	.108	.117
139	5.2	65.0	29.7	.1	.0	.0	.100	.111	.122
Alex—Nov. 9, 1964									
130	16.3	47.2	34.7	1.8	0.0	0.0	0.090	0.105	0.127
140	8.9	17.1	74.0	.0	.0	.0	.132	.145	.159
150	3.0	25.2	71.3	.5	.0	.0	.130	.140	.154
160	3.8	27.4	68.8	.0	.0	.0	.128	.138	.150
170	3.7	40.0	56.3	.0	.0	.0	.119	.131	.142
180	2.6	15.4	80.5	1.5	.0	.0	.142	.154	.169
190	2.7	10.6	82.5	4.2	.0	.0	.150	.164	.180
200	2.6	7.6	84.3	5.5	.0	.0	.158	.174	.190
210	1.8	4.7	88.0	5.5	.0	.0	.164	.180	.193
220	2.6	6.2	82.3	8.9	.0	.0	.170	.186	.203

¹Discharge: Anadarko—1,680 ft³/s (May 13), 3,880 ft³/s (Nov. 6); Verden—3,560 ft³/s; Chickasha—1,760 ft³/s (June 26), 2,010 ft³/s (May 16); Alex—1,120 ft³/s (June 27), 4,170 ft³/s (Nov. 9).

²Insufficient depth of bed material on bedrock to obtain full sample with US BM-54 sampler.

³Insufficient sample for laboratory analysis.

⁴Sampler bit into silty bank material.

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